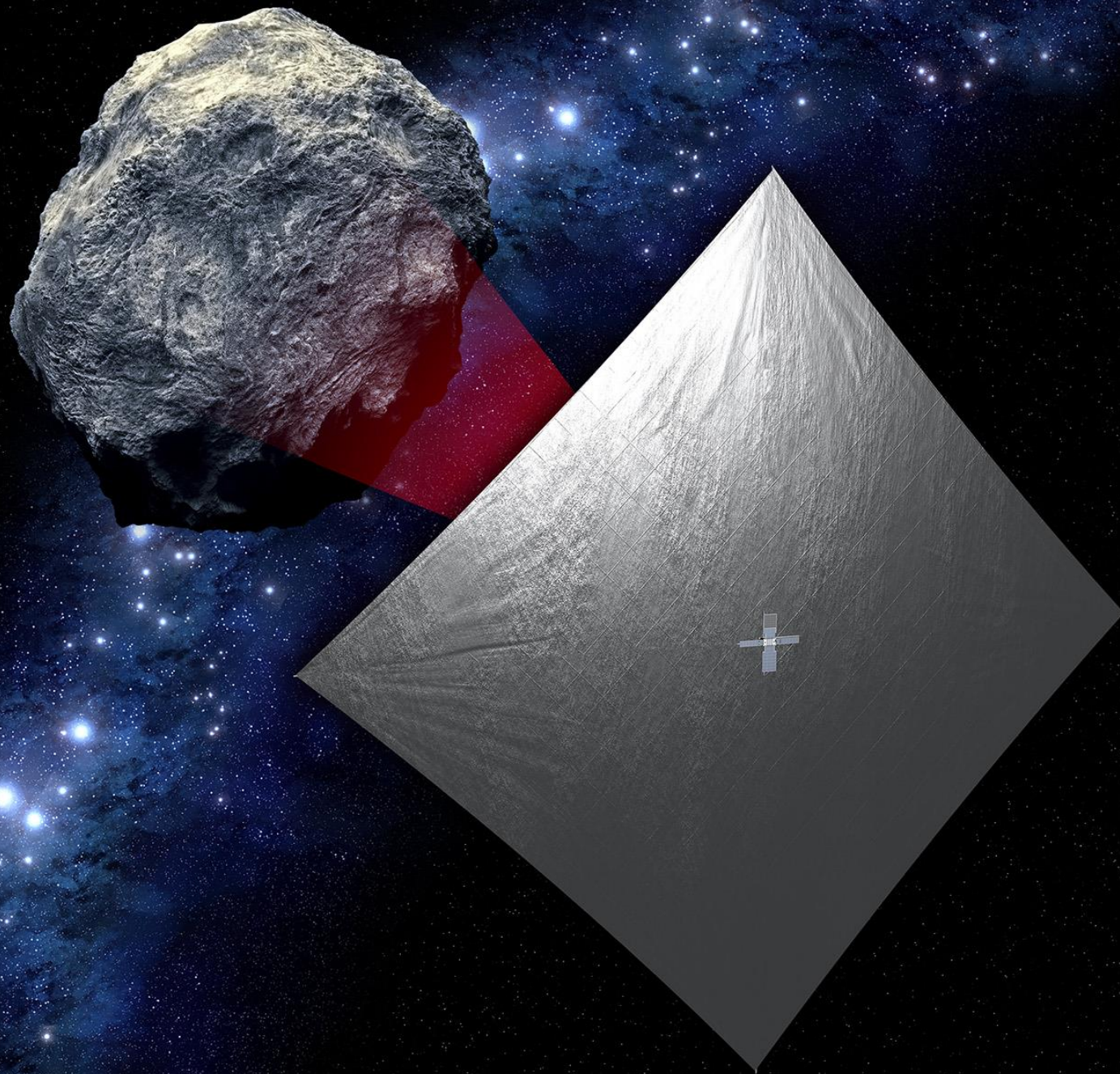


Near Earth Asteroid (NEA) Scout



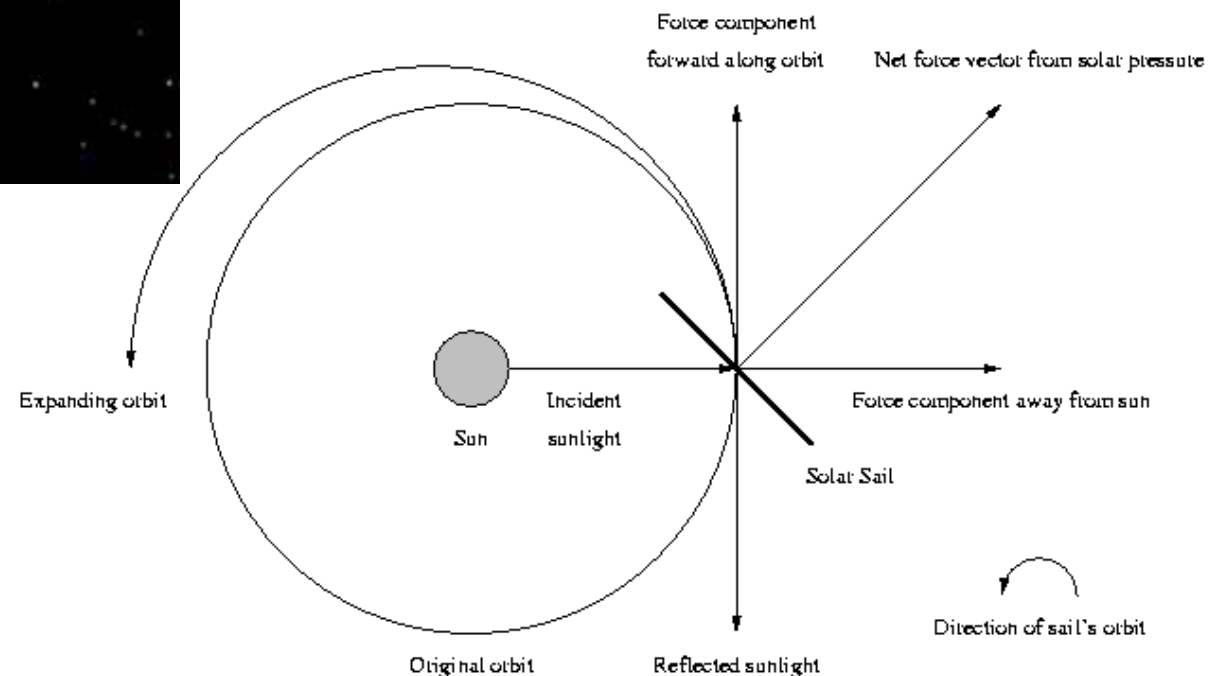
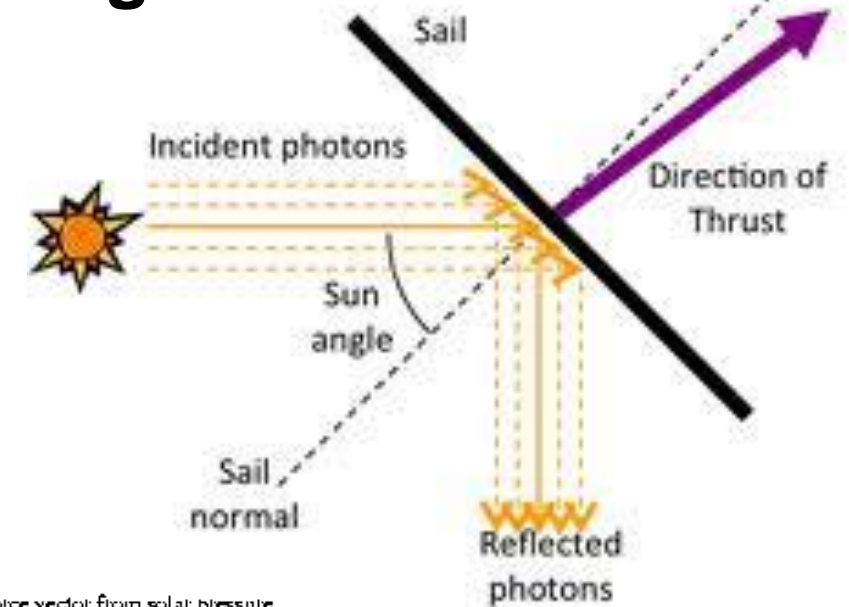
Les Johnson
NASA MSFC
Advance Concepts Office
les.johnson@nasa.gov



- **What is a solar sail?**
- **A brief history of solar sailing**
- **NASA's Near Earth Asteroid Scout mission**

How does a solar sail work?

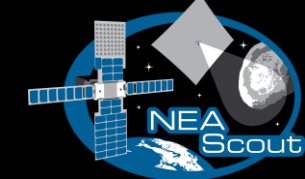
Solar sails use photon “pressure” or force on thin, lightweight reflective sheet to produce thrust.



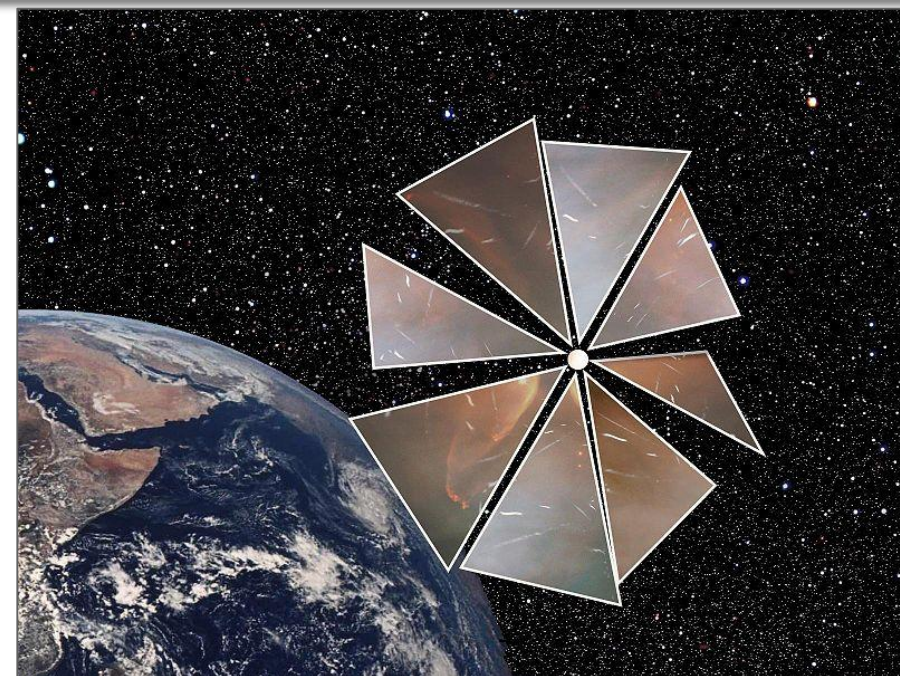
- What is a solar sail?
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- NASA's Near Earth Asteroid Scout mission



The Planetary Society's Cosmos-1 (2005)



- 100 kg spacecraft
- 8 triangular sail blades deployed from a central hub after launch by the inflating of structural tubes.
 - Sail blades were each 15 m long
 - Total surface area of 600 square meters
- Launched in 2005 from a Russian Volna Rocket from a Russian Delta III submarine in the Barents Sea:

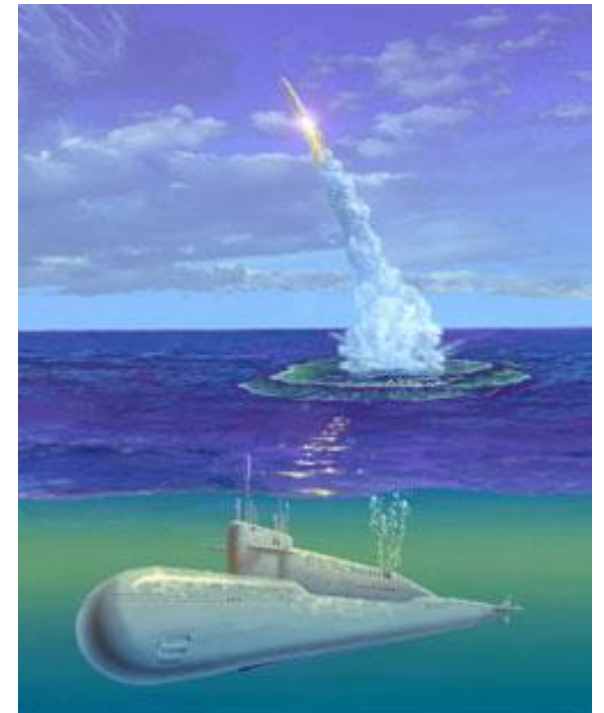
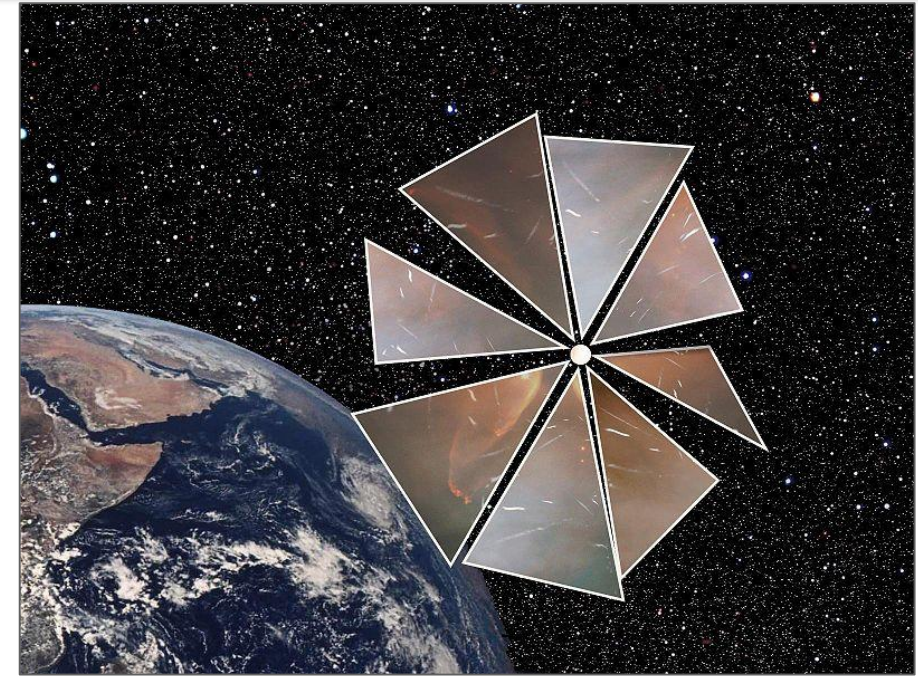




The Planetary Society's Cosmos-1 (2005)



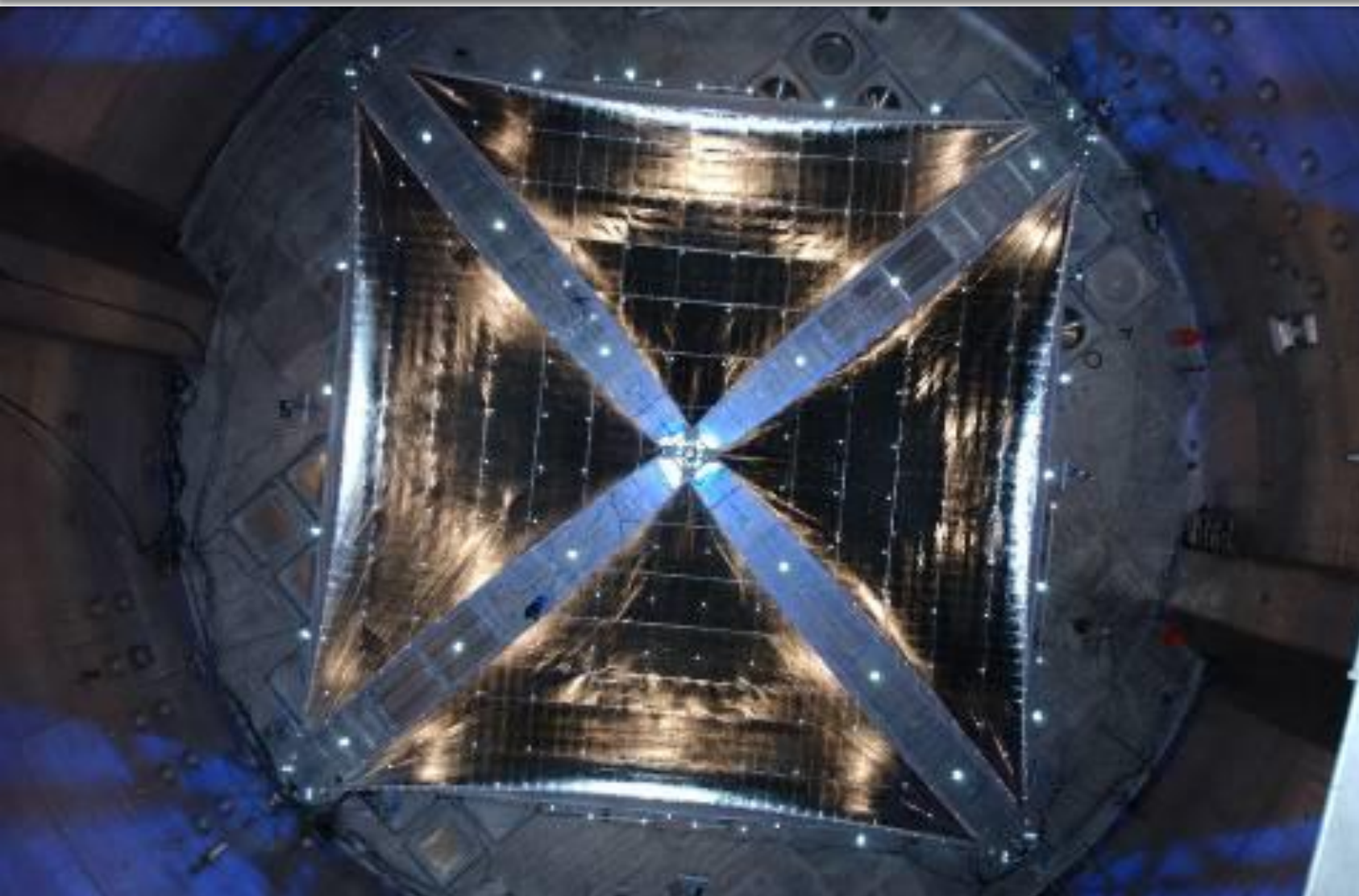
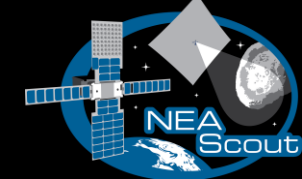
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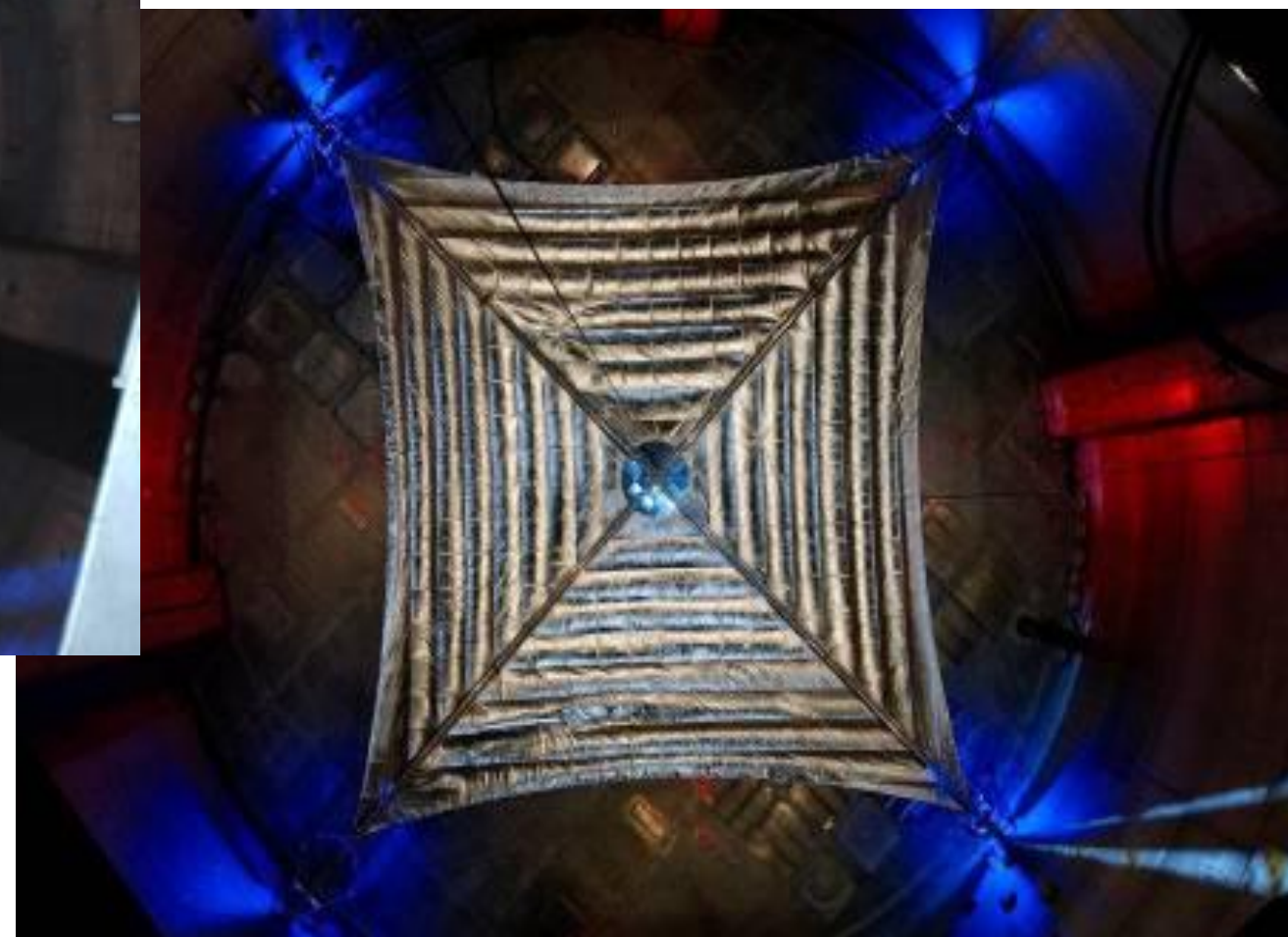
Rocket Failed



NASA Ground Tested Solar Sails in the Mid-2000's

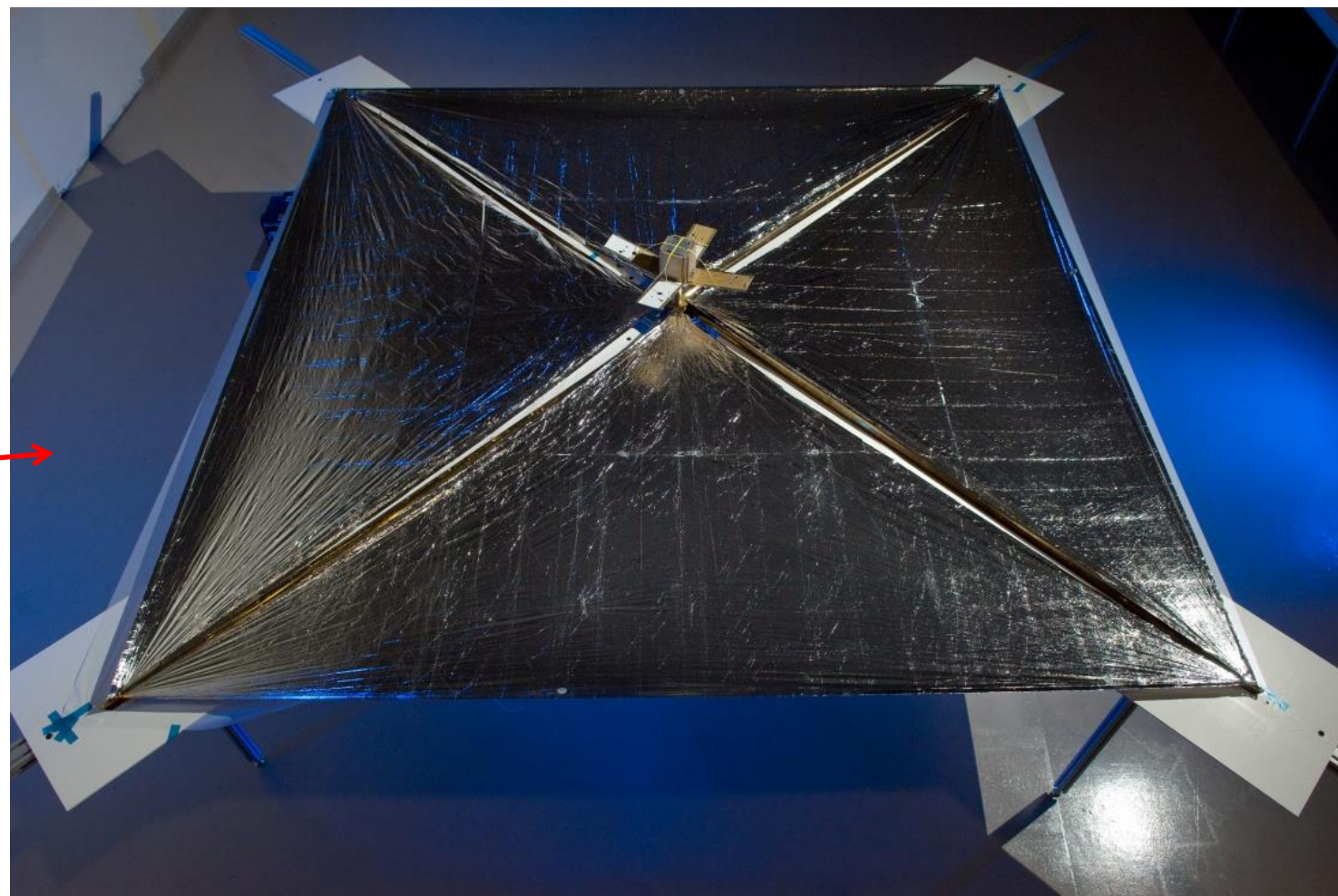
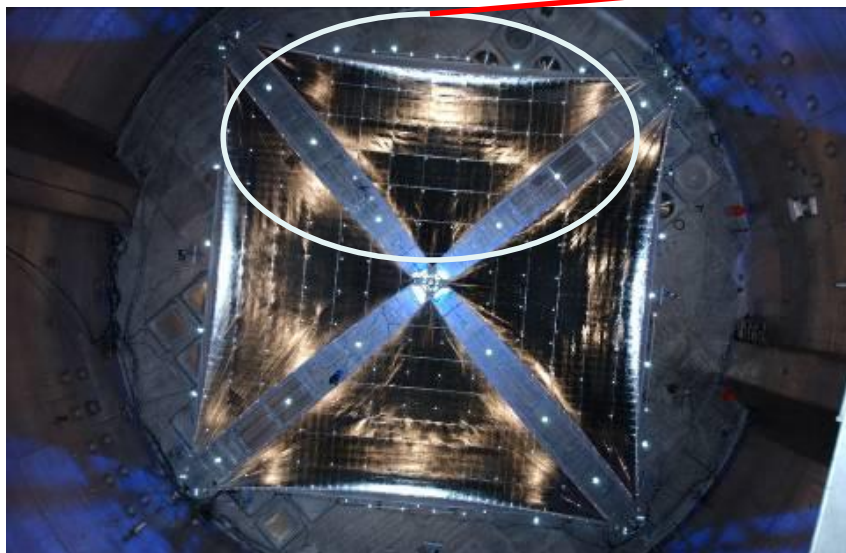


**Two 400 square meter sail
were autonomously deployed
and tested at Plumbrook**



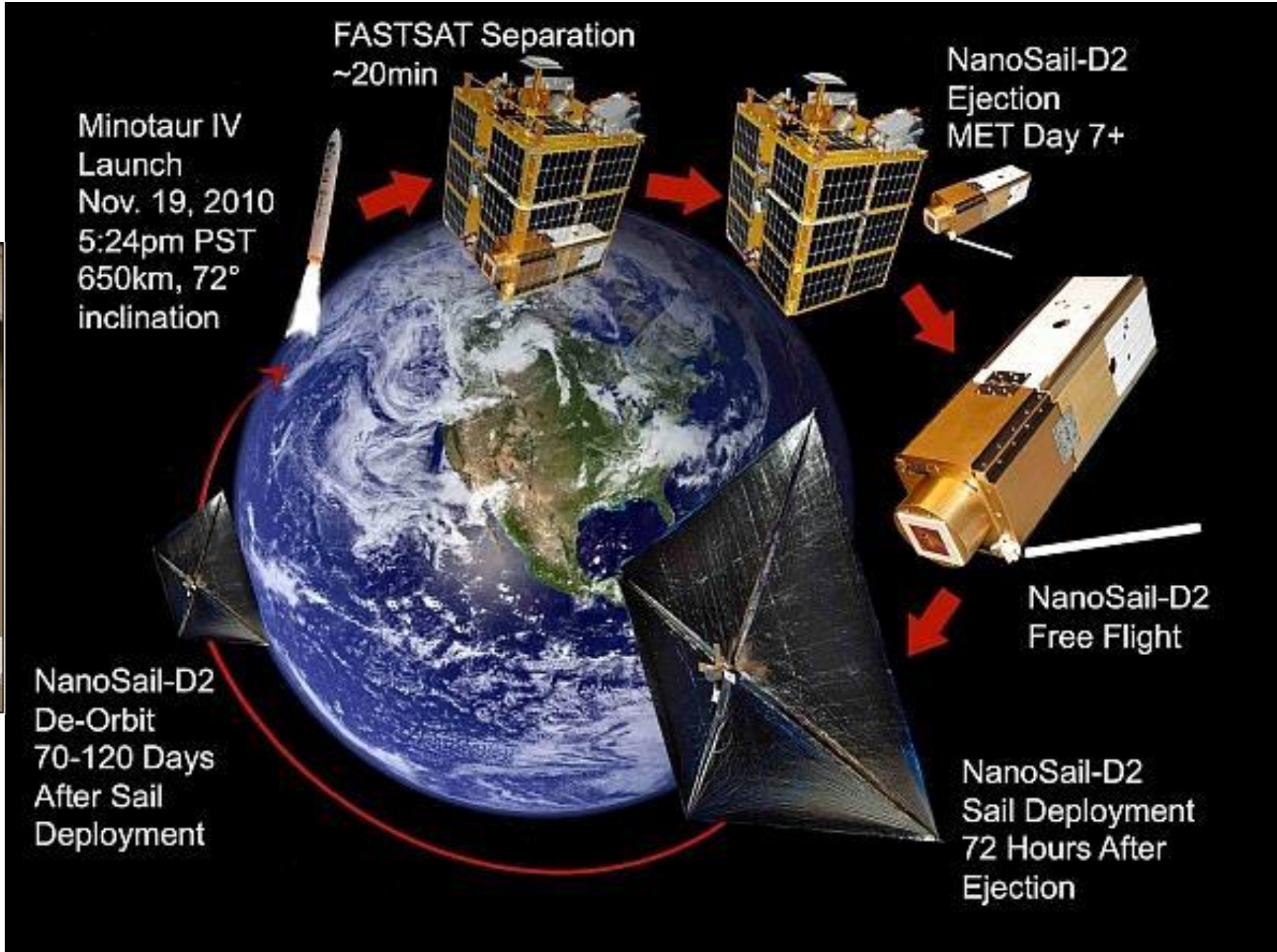
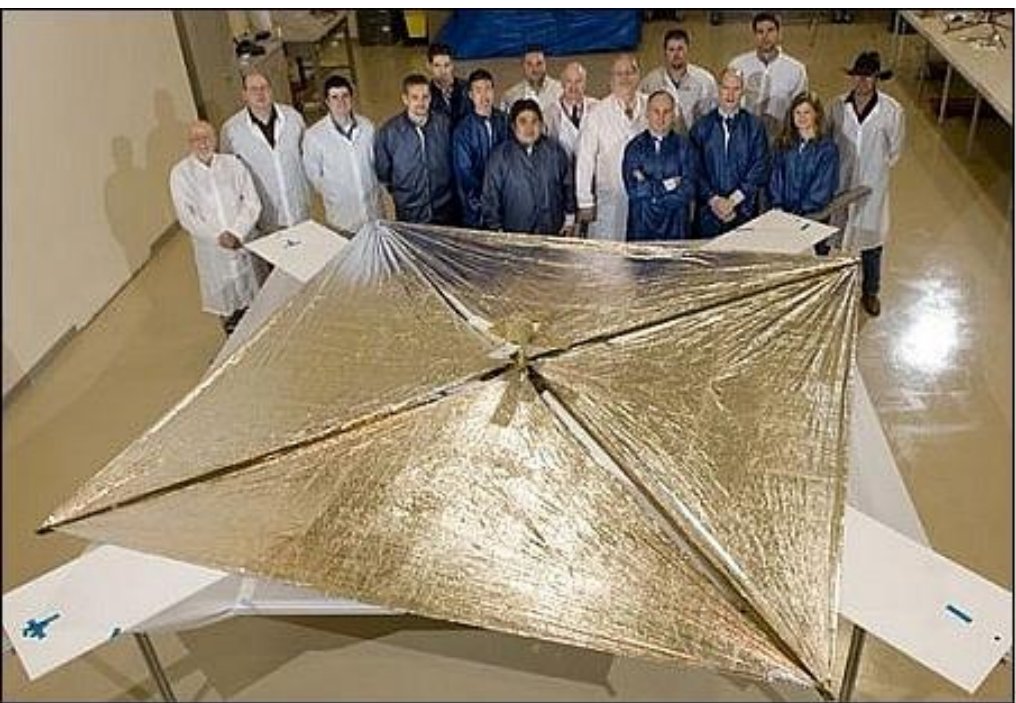
Mission Description:

- 10 m² sail
- Made from tested ground demonstrator hardware





NanoSail-D2 Mission (2010)



Minotaur IV
Launch
Nov. 19, 2010
5:24pm PST
650km, 72°
inclination

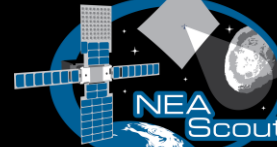
FASTSAT Separation
~20min

NanoSail-D2
Ejection
MET Day 7+

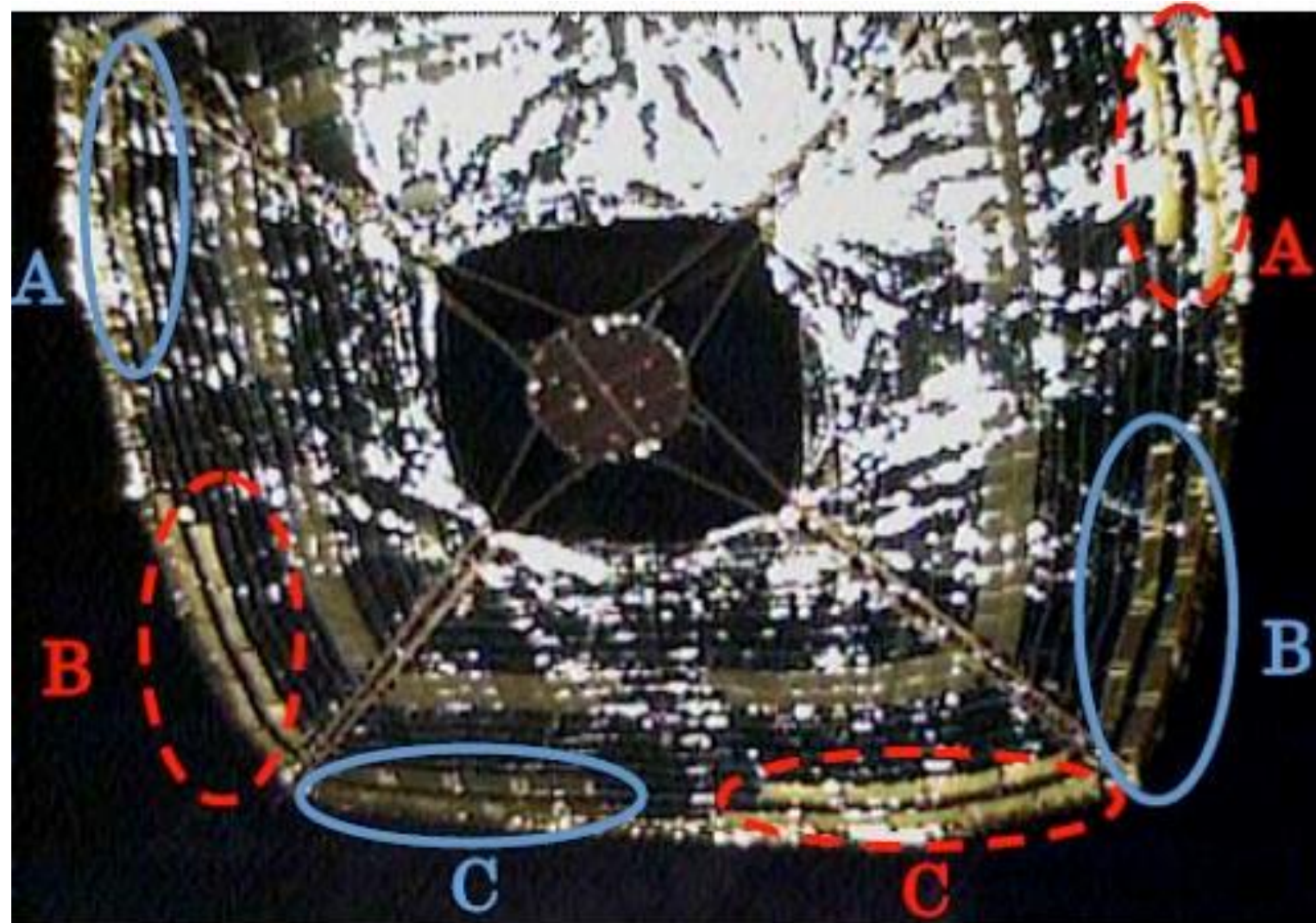
NanoSail-D2
Free Flight

NanoSail-D2
Sail Deployment
72 Hours After
Ejection

NanoSail-D2
De-Orbit
70-120 Days
After Sail
Deployment

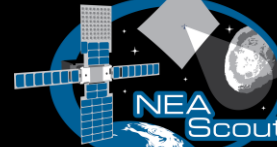


Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS)



Liquid crystal device power was off.

Liquid crystal device power was on.

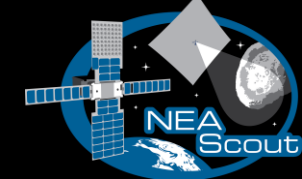


Fortunately, IKAROS accomplished with Icarus could not...





Sunjammer Solar Sail Demonstration Mission

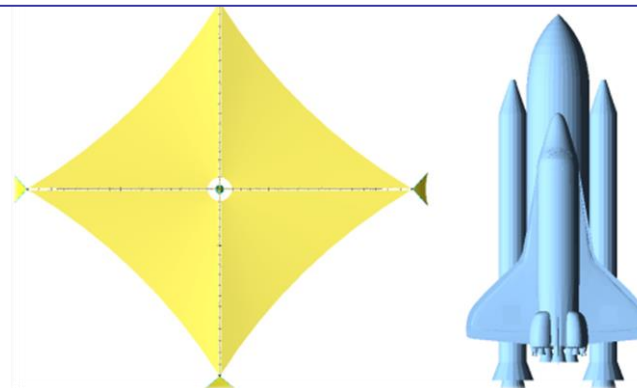


83 m² ISP L'Garde Solar Sail 2004



318 m² ISP L'Garde Solar Sail 2005

STMD Technology Demonstration Mission (TDM)



Based on one of the 400 m² NASA Demonstrators:

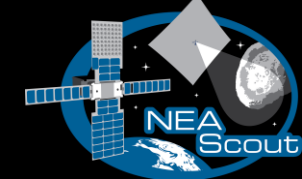
- Cold Rigidization Boom Technology
- Aluminized Sun Side
- High Emissivity Eclipse Surface
- Beam Tip Vane Control



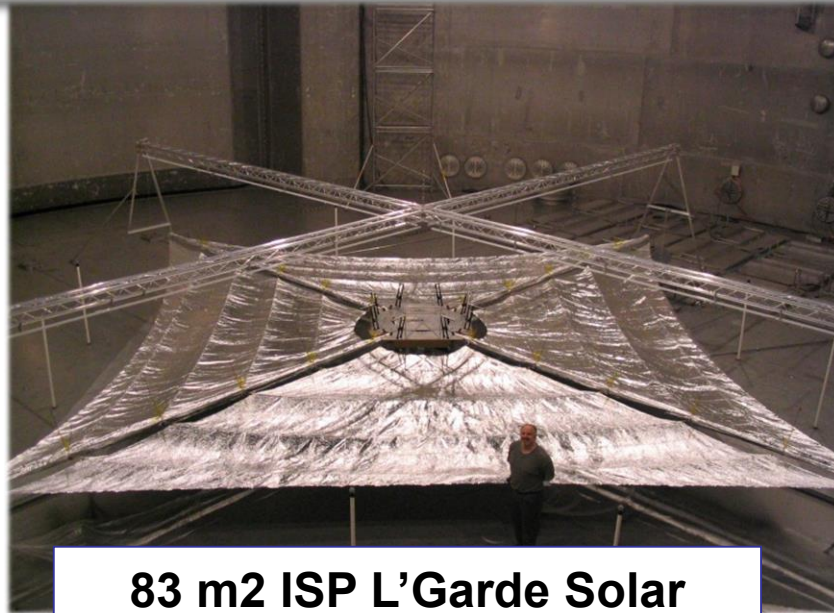
1200 m² L'Garde Sunjammer was to launch in 2015



Sunjammer Solar Sail Demonstration Mission



Canceled

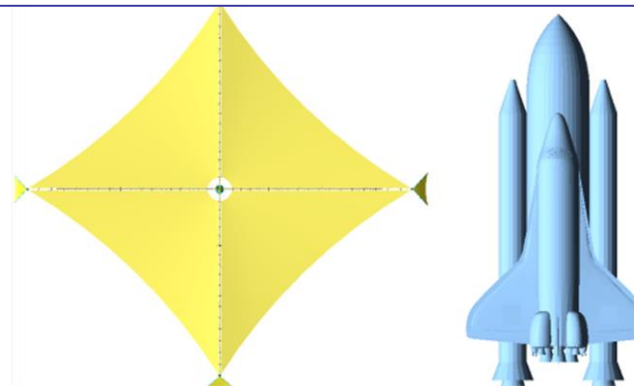


83 m² ISP L'Garde Solar Sail 2004



318 m² ISP L'Garde Solar Sail 2005

STMD Technology Demonstration Mission (TDM)

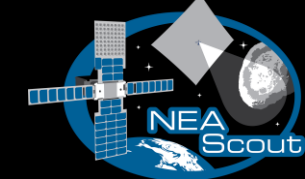


Based on one of the 400 m² NASA Demonstrators:

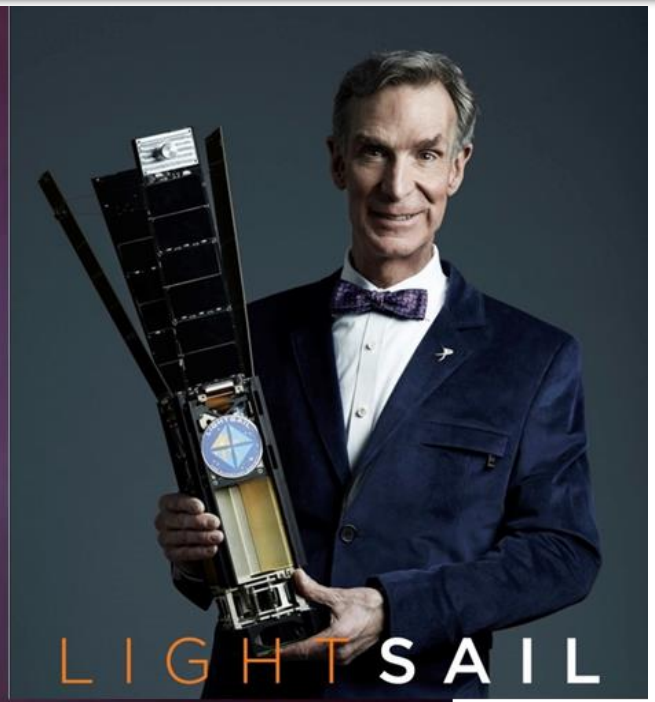
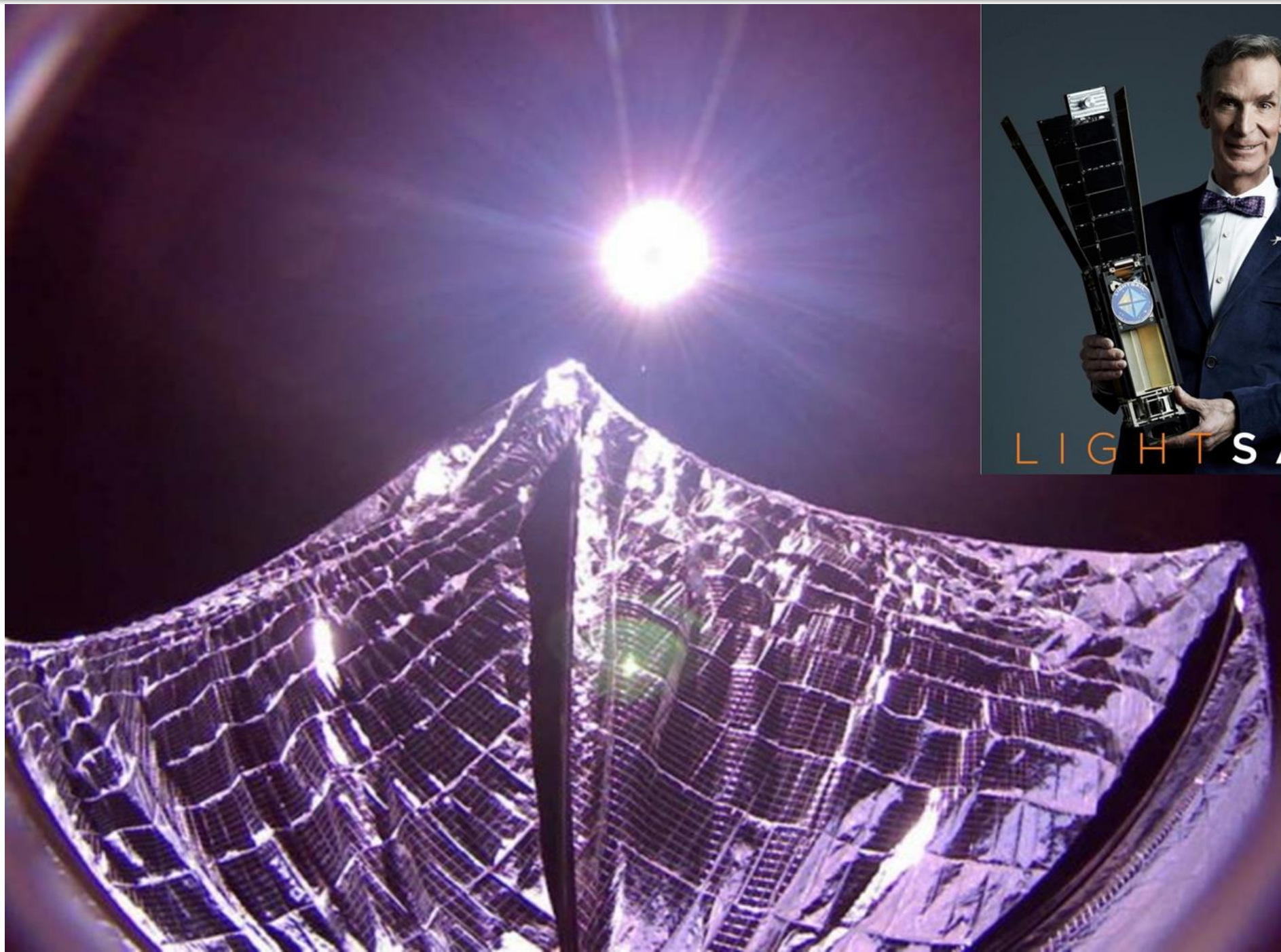
- Cold Rigidization Boom Technology
- Aluminized Sun Side
- High Emissivity Eclipse Surface
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1200 m² L'Garde Sunjammer was to launch in 2015



2015's LightSail-A (The Planetary Society)

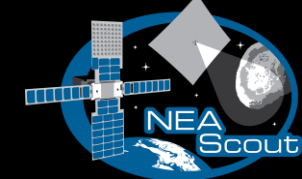


32 m²
No active 'sailing'
3U cubesat

- What is a solar sail?
- A brief history of solar sailing
- • **NASA's Near Earth Asteroid Scout mission**



Near Earth Asteroid Scout



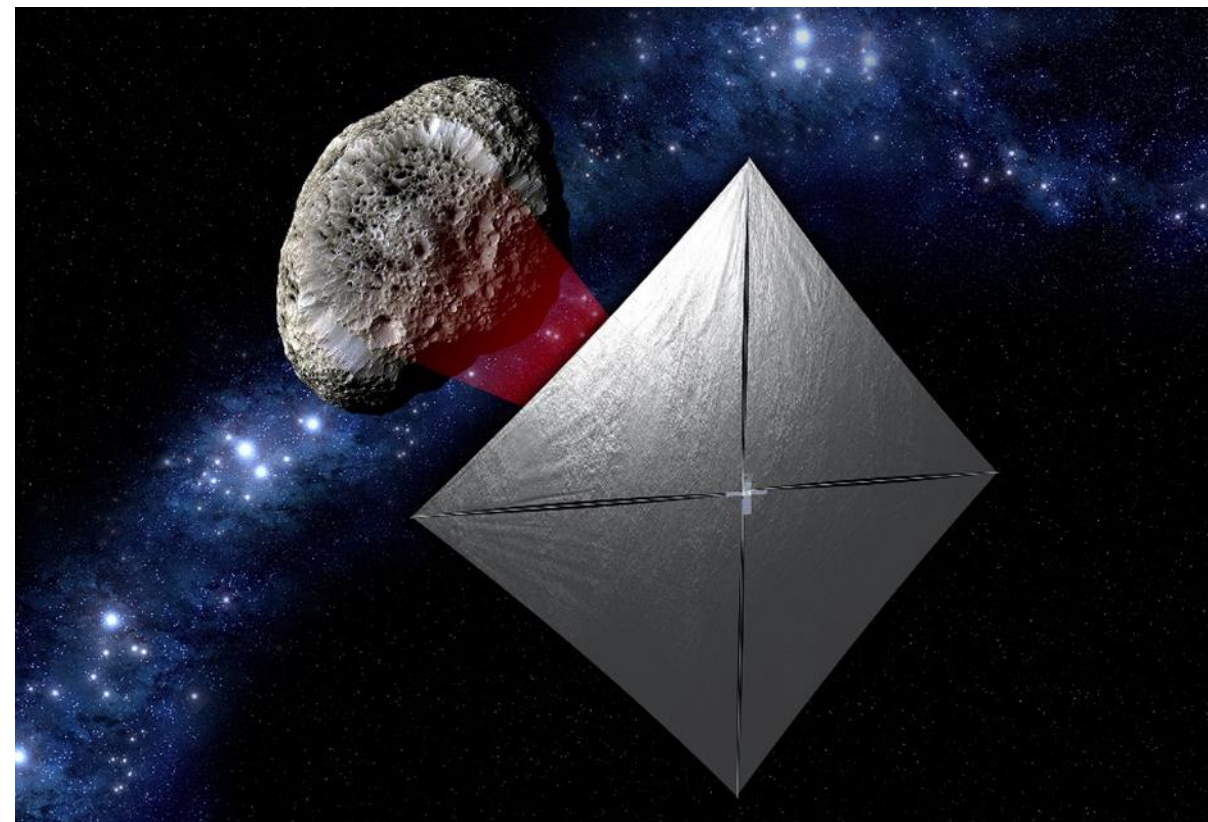
The Near Earth Asteroid Scout Will

- Image/characterize a NEA during a slow flyby
- Demonstrate a low cost asteroid reconnaissance capability

Key Spacecraft & Mission Parameters

- 6U cubesat (20cm X 10cm X 30 cm)
- ~86 m² solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2018)
- 1 AU maximum distance from Earth

Leverages: combined experiences of MSFC (PM, SE and Solar Sail) and JPL (flight system bus, instrument and science) with support from GSFC, JSC, & LaRC



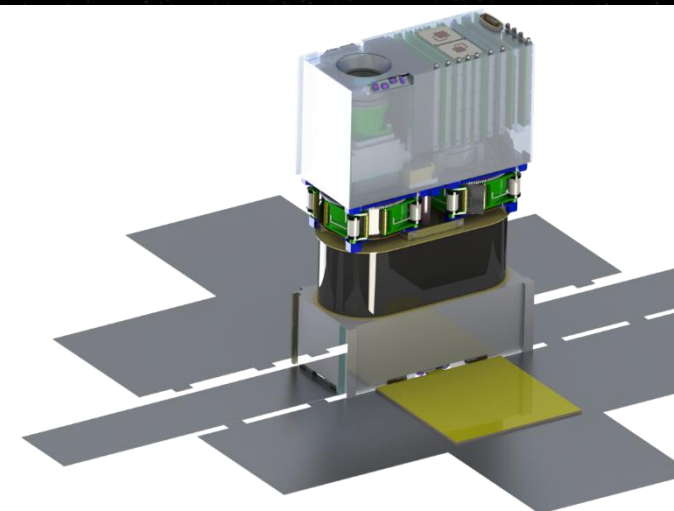
Target Reconnaissance with medium field imaging

Shape, spin, and local environment



Close Proximity Imaging

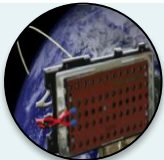
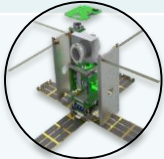

Local scale morphology, terrain properties, landing site survey



NEA Scout Sponsored by HEOMD AES

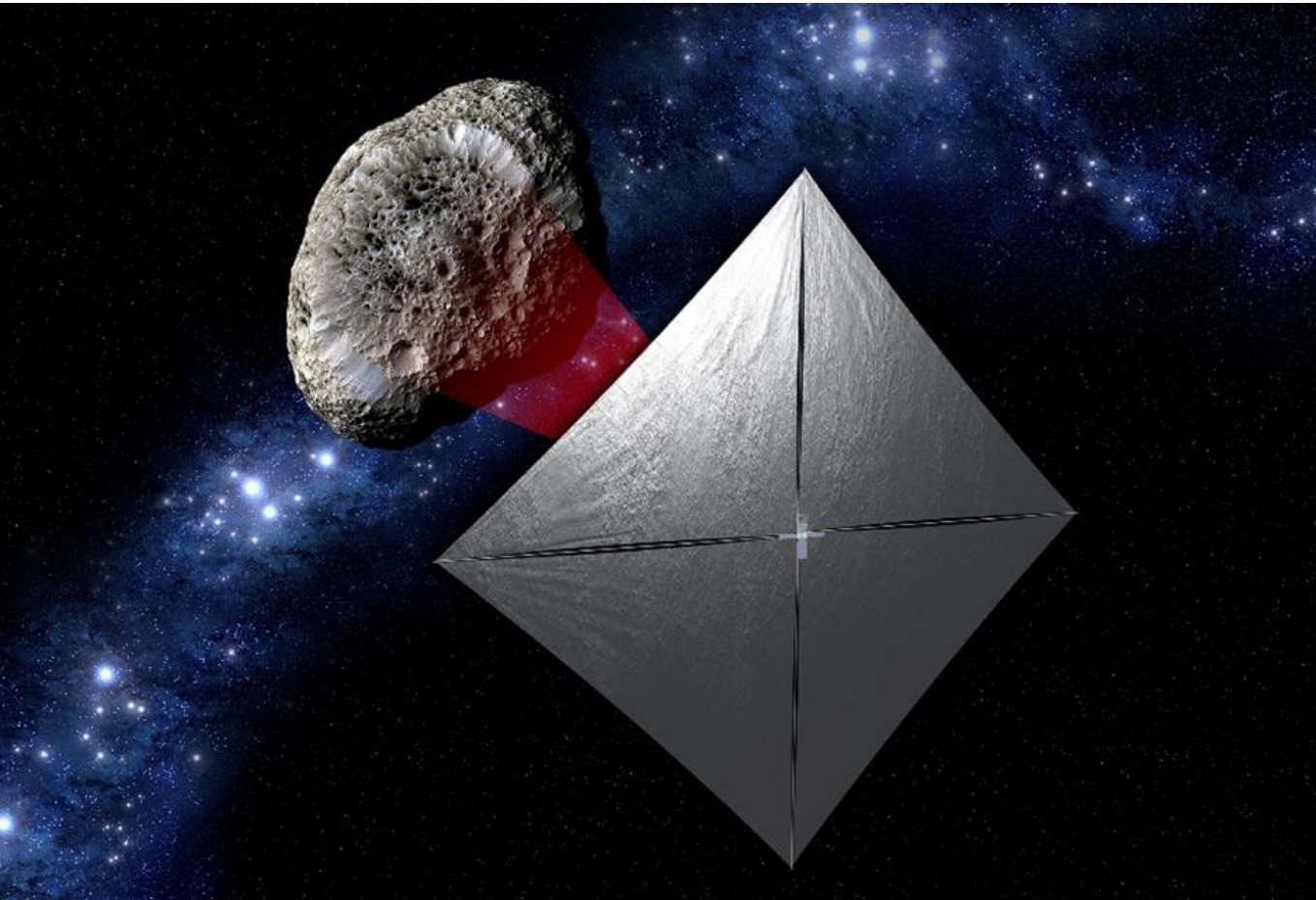


- HEOMD's Advanced Exploration Systems (AES) selected 3 cubesats for flight on SLS EM1
- **Primary selection criteria:**
 - Relevance to Space Exploration Strategic Knowledge Gaps (SKGs)
 - Life cycle cost
 - Synergistic use of previously demonstrated technologies
 - Optimal use of available civil servant workforce

Payload <i>NASA Centers</i>	Strategic Knowledge Gaps Addressed	Mission Concept
BioSentinel <i>ARC/JSC</i> 	Human health/performance in high-radiation space environments <ul style="list-style-type: none"> • Fundamental effects on biological systems of ionizing radiation in space environments 	Study radiation-induced DNA damage of live organisms in cis-lunar space; correlate with measurements on ISS and Earth
Lunar Flashlight <i>JPL/MSFC</i> 	Lunar resource potential <ul style="list-style-type: none"> • Quantity and distribution of water and other volatiles in lunar cold traps 	Locate ice deposits in the Moon's permanently shadowed craters
Near Earth Asteroid (NEA) Scout <i>MSFC/JPL</i> 	Human NEA mission target identification <ul style="list-style-type: none"> • NEA size, rotation state (rate/pole position) How to work on and interact with NEA surface <ul style="list-style-type: none"> • NEA surface mechanical properties 	Flyby and characterize one NEA that is candidate for a human mission



NEA Scout Roles and Responsibilities



Near Earth Asteroid Scout

- Project Manager: Leslie McNutt (MSFC)
- Science PI: Julie Castillo-Rogez (JPL)
- Solar Sail PI: Les Johnson (MSFC)
- Spacecraft System: JPL
- Solar Sail System: MSFC



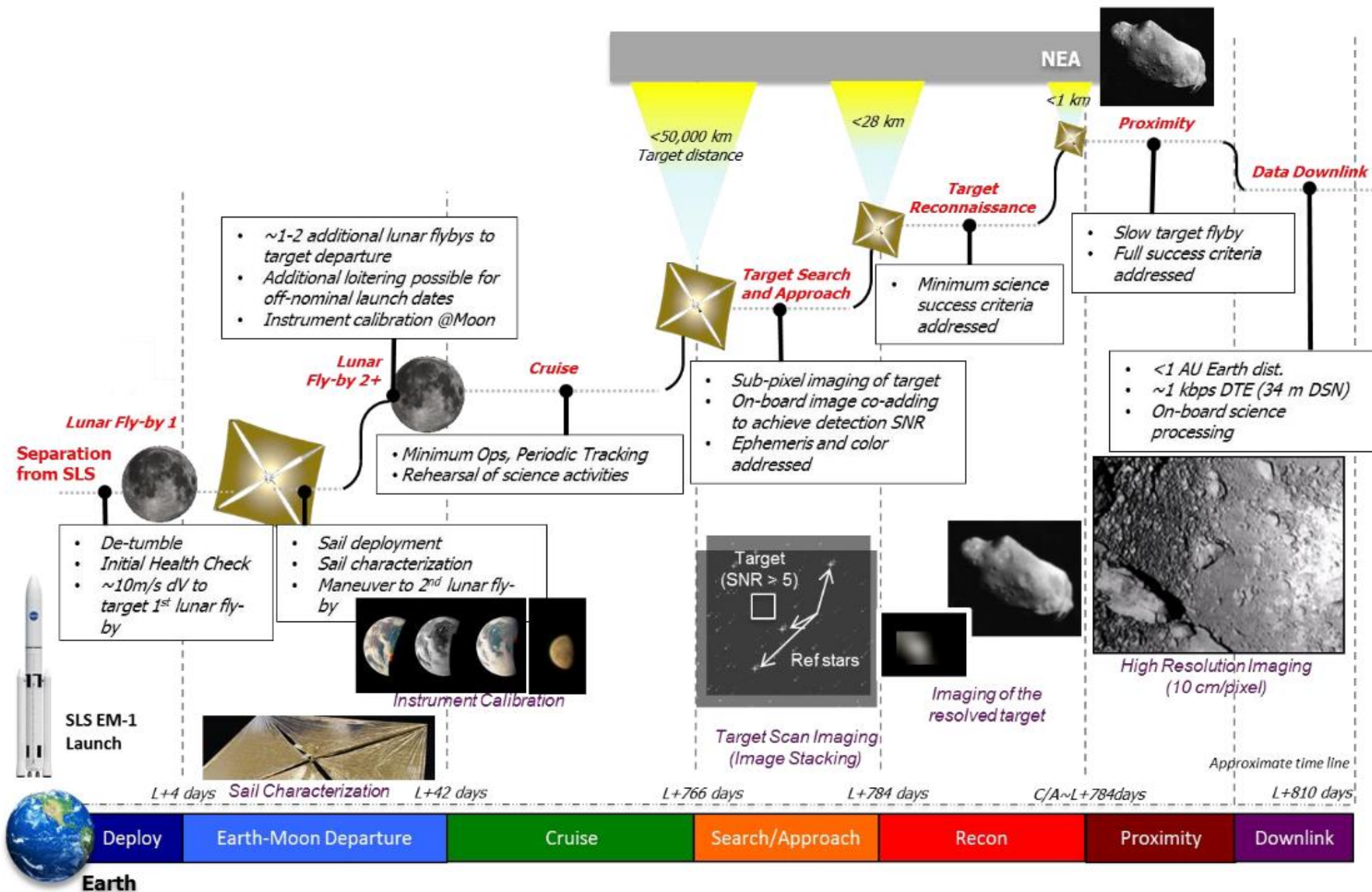
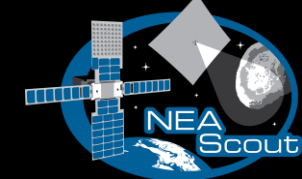
L1 Science Requirements



- **NEA SCOUT SHALL HAVE THE CAPABILITY TO ADDRESS KEY STRATEGIC KNOWLEDGE GAPS AT A NEAR EARTH ASTEROID**
- Full Success Criteria: Fly by a near Earth asteroid and acquire images sufficient to determine the target volume, shape model, asteroid spectral type and meteorite analogs, rotational properties (pole position, rotation period), orbit, debris/dust field in local environment, and regolith characteristics.
- Minimum Success Criteria: Fly by a near Earth asteroid and acquire images sufficient to estimate the target volume, the asteroid spectral type, determine rotational properties (pole position, rotation period), and orbit.
- Rationale: This requirement addresses the need to fill Strategic Knowledge Gaps related to asteroids as a precursor to subsequent safe and successful human missions. The data obtained will also support the advancement of science interests in asteroids.

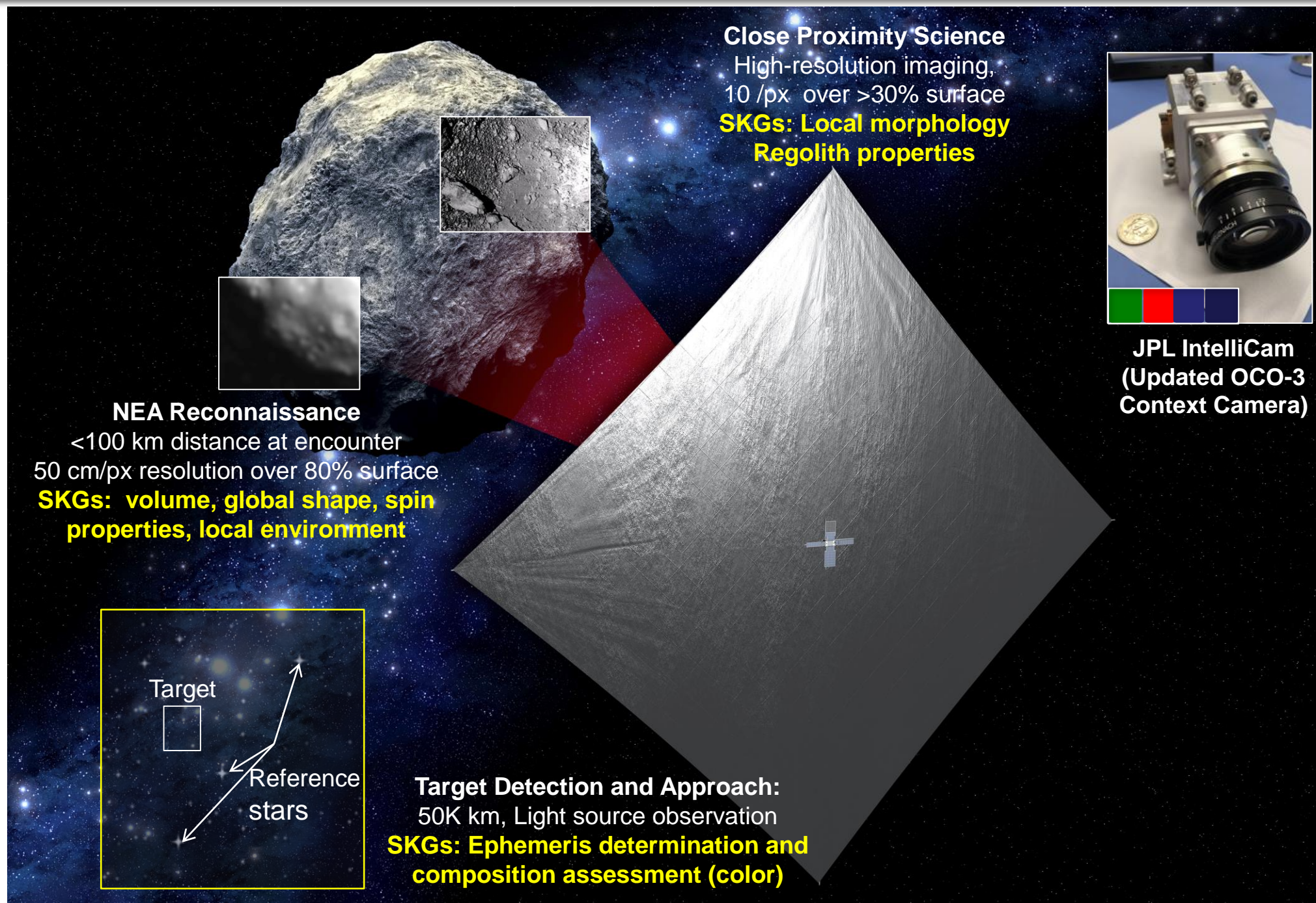
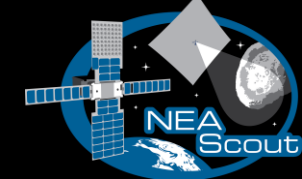


Concept of Operations Overview





Near Earth Asteroid Scout Asteroid Flyby



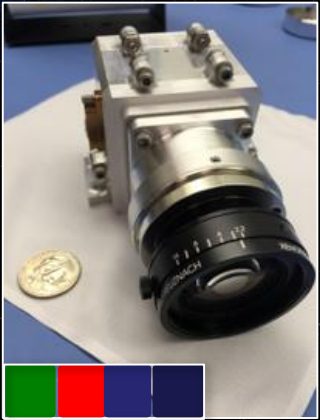
Close Proximity Science
High-resolution imaging,
10 /px over >30% surface
SKGs: Local morphology
Regolith properties

NEA Reconnaissance
<100 km distance at encounter
50 cm/px resolution over 80% surface
SKGs: volume, global shape, spin
properties, local environment

Target Detection and Approach:
50K km, Light source observation
SKGs: Ephemeris determination and
composition assessment (color)

JPL IntelliCam
(Updated OCO-3
Context Camera)

Target
Reference stars





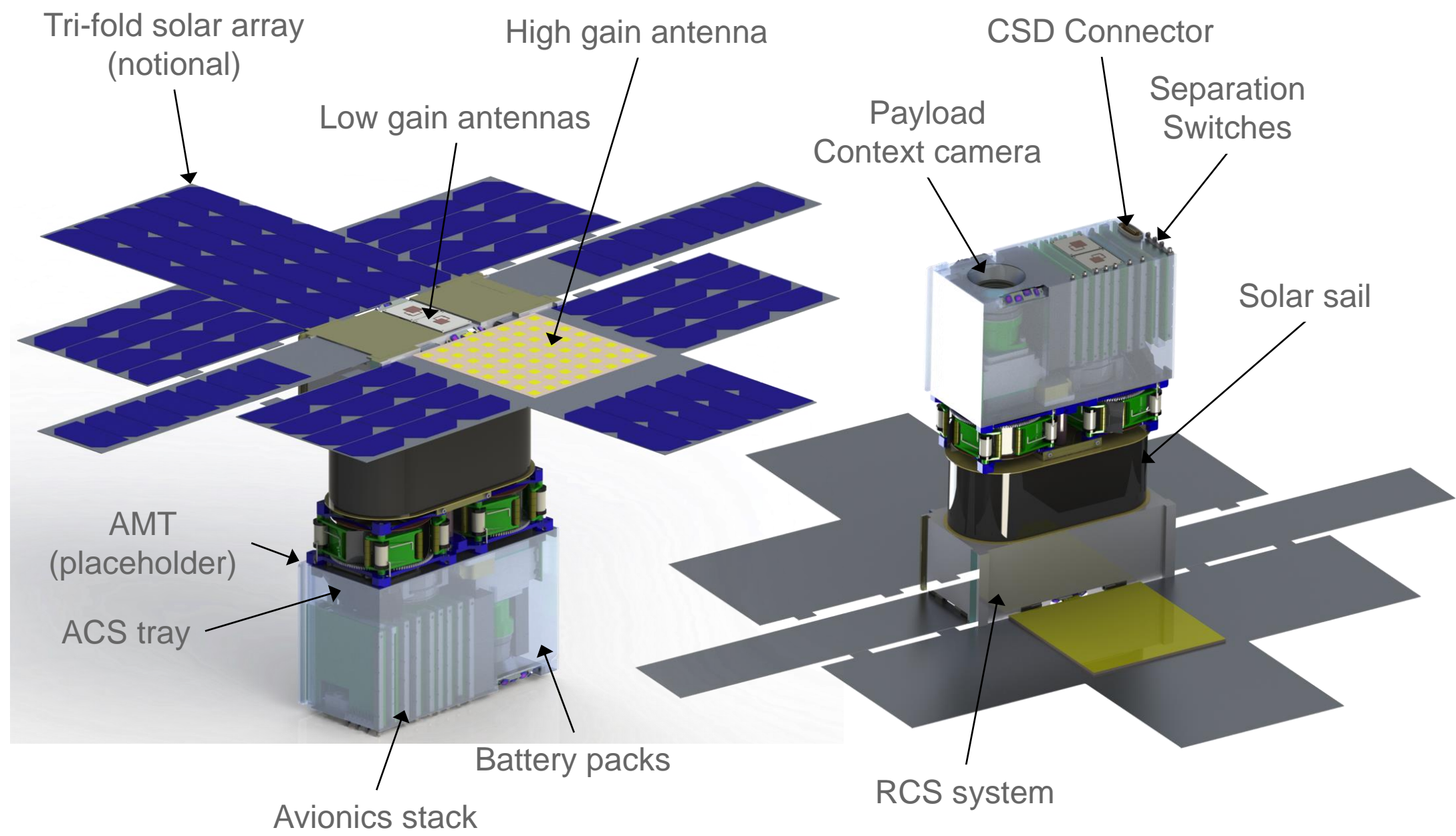
Baseline Target: 1991 VG



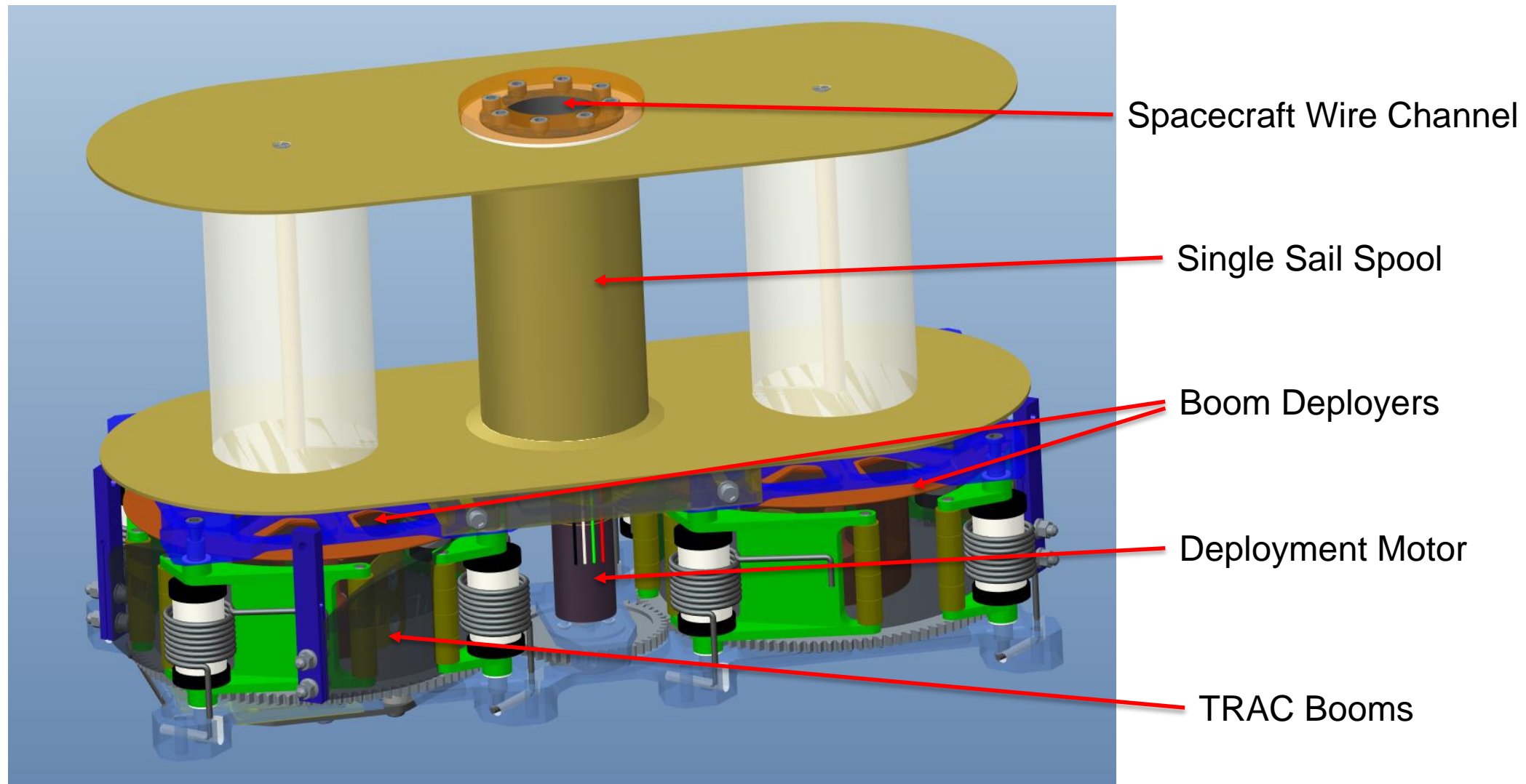
- Diameter ~ 5-12 meters
- Albedo is unknown
- Position is known within 2700 km ($1-\sigma$) but optical observation opportunity in July '17 will decrease uncertainty to a few 100s km
- Rotation period between a few minutes and less than 1 hour
- Unlikely to have a companion
- Unlikely to retain an exosphere or dust cloud
 - Solar radiation pressure sweeps dust on timescales of hours or day



NEA Scout Flight System Configuration



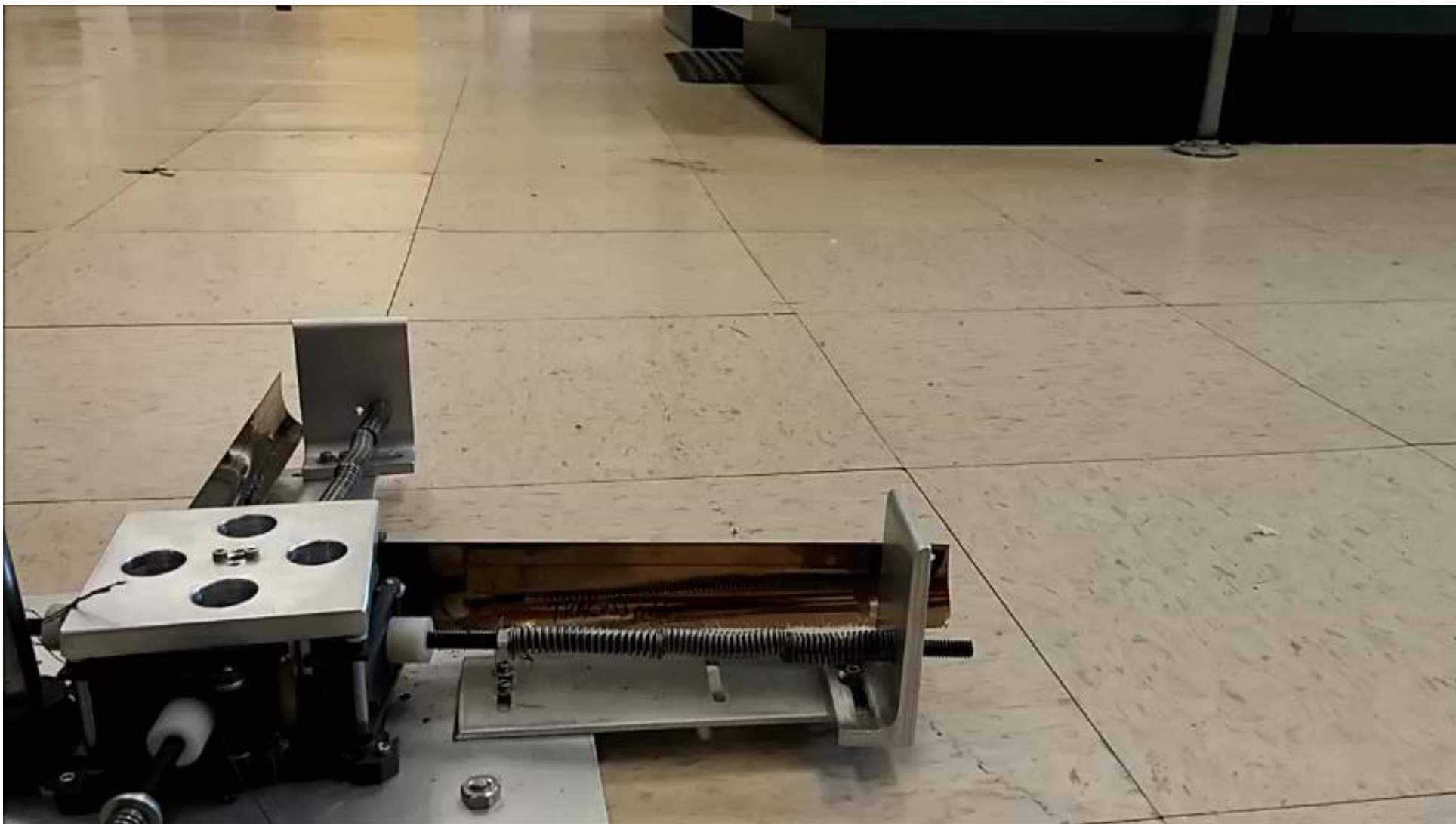
Solar Sail Subsystem Overview



Solar Sail Subsystem without sail, Credit: NASA



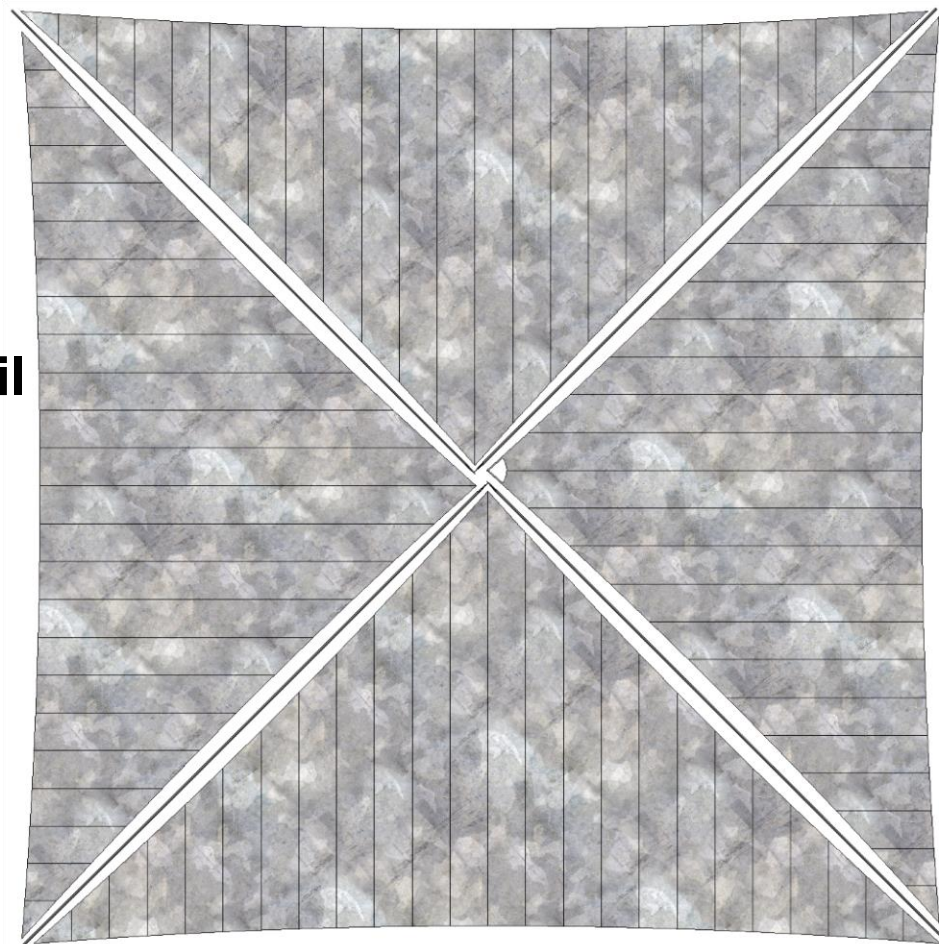
Test Deployment with Linear Springs





NEA Scout Approximate Scale

Deployed Solar Sail



School Bus



Human



6U Stowed Flight System



Folded, spooled and packaged in here



QUESTIONS?

